Wallops Orbital Tracking Station (WOTS)
Upgrade Process
Operations Concept & Requirements
for
WOTS Master Subsystem
&
WOTS Remote Nodes Subsystem

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Version 1.0

NASA
National Aeronautics & Space Administration
Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, Virginia 23337

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INTRODUCTION

1.1 Identification

This is the operations concept and high level software requirements specification document, as it pertains to the Wallops Orbital Tracking Station (WOTS) Master Subsystem and Remote Nodes Subsystem, which is an element of the major upgrade process being performed at the Wallops Main Base orbital tracking station facility. This document is being prepared according to the guidelines set forth in the WOTS Upgrade Software Development and Management Plan.

1.2 Scope

This document pertains only to the Master and Remote Nodes Subsystems, which will be the primary point of control for the WOTS after it has been upgraded. The rationale for the division of the tracking station control into a Master Subsystem and a Remote Nodes Subsystem is discussed in the WOTS Upgrade Software Development and Management Plan, which is the parent for this document. The Operations Concept and Requirements document is the point of beginning for the definition the requirements for both the Master Subsystem and the Remote Nodes Subsystem. It has been combined with the operations concept, since the requirements are very closely linked to the operations performed by the tracking station, and in many cases are driven directly by them.

1.3 Purpose

As the number of spacecraft (S/C) requiring support from the WOTS increases, and the WOTS workload becomes larger, the capability of the current tracking station must grow accordingly. It is the purpose of this document to specify all known requirements for the new Master and Remote Nodes Subsystems within the upgraded tracking station as it transitions from a largely manual operation to a highly automated operation, using the very latest technology in the form of computer interfaced telemetry hardware and real time interactive computer control with a well developed Graphics User Interface (GUI).

1.4 Status & Schedule

This document is a compendium of the Master and Remote Nodes Subsystem requirements as they are currently known, and as they relate to the other hardware and software elements of the upgrade. It is complete as of its initial release date. If, in the process of hardware procurement, other requirements surface, this document will be updated so that there will be traceability throughout the life of the project.

The WOTS upgrade process is being directed by the Telemetry Systems Section (Code 822.3) within the Instrumentation Engineering Branch (Code 822) of the Engineering Division (Code 820), Suborbital Projects and Operations Directorate at

the NASA Goddard Space Flight Center (GSFC), Wallops Flight Facility (WFF). This document, and all software, are being developed under the auspices of the Software and Analysis Section (Code 822.4) of Code 822.

The initial upgrade process is due to be completed by the end of CY 97. Figure 1 shows a high level development and deployment timeline for the software and software products throughout the life of the project.

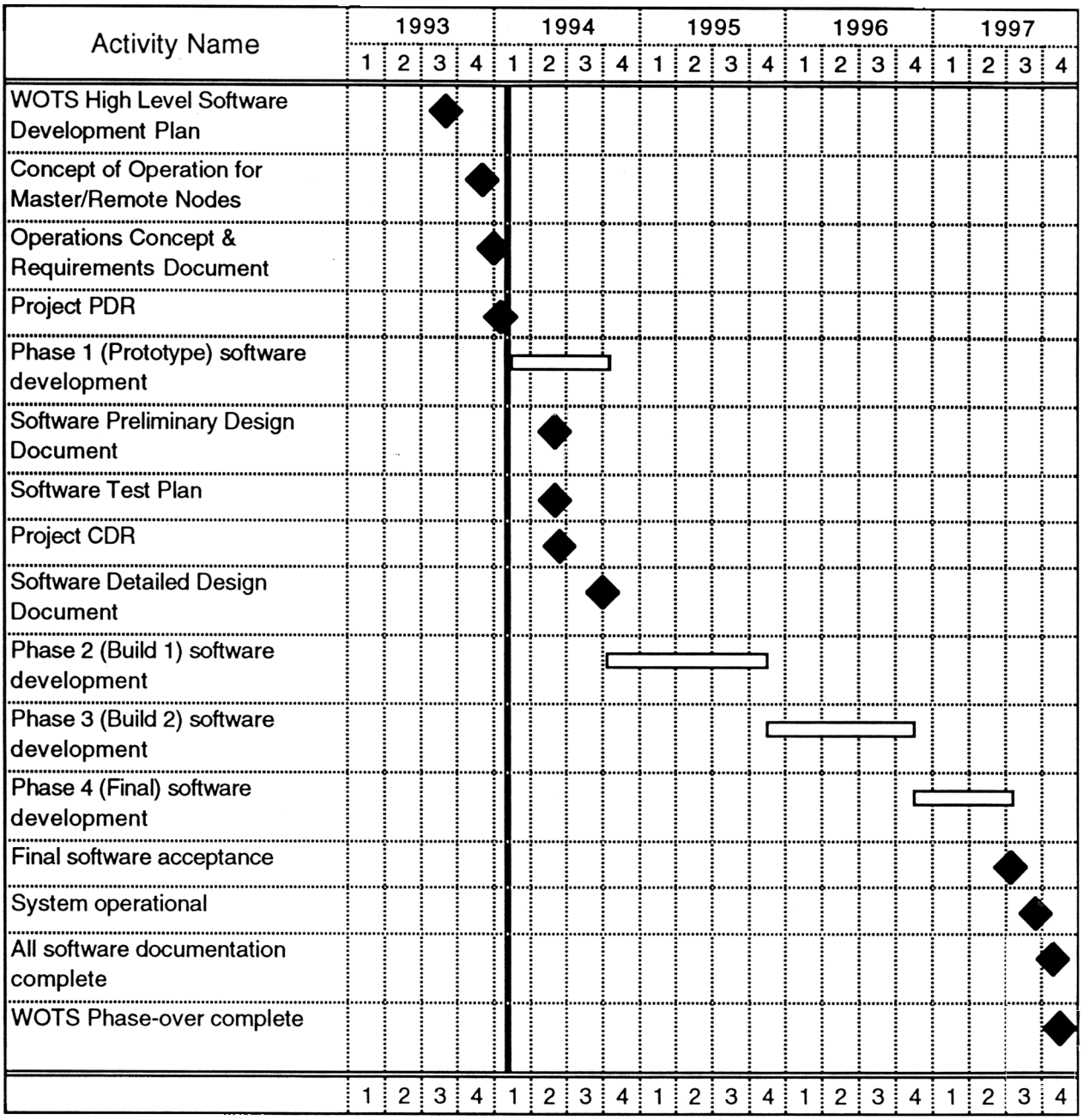

Figure 1
WOTS Upgrade Timeline

RELATED DOCUMENTATION

2.1 Parent Documents

The following higher level documents are considered parents, from which this document's scope and content derive.

No Control #	WOTS Upgrade Process Software Development and Management Plan, Document #1, Version 1.0, In Preparation.

2.2 Applicable Documents

The following documents have been used in the formation of this document, and are directly applicable to this document.

No Control #	Instrumentation Handbook, Volume II, Telemetry Facilities and Systems, NASA/GSFC/WFF, January, 1989.
SEL-81-305	Recommended Approach to Software Development, Rev 3, Software Engineering Laboratory Series, NASA/GSFC, June 1992.
SEL-84-101	Managers Handbook for Software Development, Rev ?, Software Engineering Laboratory Series, NASA/GSFC, November 1990.
No Control #	Wallops Orbital Tracking & Range Scheduling WOTRS, N-Spacecraft Requirement Specification, prepared by Computer Sciences Corporation for Task #49 on NASA contract NAS5-30999, Version 1.0, August 2, 1993

2.3 Information Documents

The following documents, although not directly applicable, amplify or clarify the information presented in this document.

No Control #	ITC '93 Telemetry Systems for Non Technical Personnel, Mr. R. G. Streich, Computer Sciences Corporation, NASA/WFF, 1993.

3.0 WOTS SYSTEM

3.1 WOTS Overview

The Wallops Orbital Tracking Station is located at the NASA Goddard Space Flight Center, Wallops Flight Facility on the Eastern Shore of Virginia. The designator, WFF, will be used to refer to this facility throughout this document. The WOTS is a major element in the Ground Network (GN) portion of the NASA Spaceflight Tracking & Data Network (STDN), which provides communication links with orbiting spacecraft via ground-based antennas and support equipment. Other elements of the ground-based portion of the STDN include the Deep Space Network (DSN) operated by the Jet Propulsion Laboratory (JPL), that portion of the GN consisting of a number of fixed world-wide stations under the direct control of the GSFC Greenbelt, Maryland facility, and several Transportable Orbital Tracking Stations (TOTS) operated by the WOTS. Table I shows some of the commonly used ground-based tracking stations, their network, and their location.

Table I - Commonly Used Tracking Stations

Designator	Network	Location
WPS	WOTS	Wallops Island, VA, USA
PFT	WOTS (TOTS#)	Poker Flat, AK, USA
DS 16 & 17	DSN	Goldstone, CA, USA
DS 46	DSN	Canberra, Australia
DS 66	DSN	Madrid, Spain
MILA	GN	Merrit Island, FL, USA
BDA	GN	Bermuda
DKR	GN	Dakar, Senegal
AGO	GN	Santiago, Chile
HAW	USAF	Kauai, HI, USA
FAI	NOAA	Fairbanks, AK, USA
VIL	Foreign	Vilspa, Spain
RED	Foreign	Redu, Belgium
TAS	Foreign	Tasmania

TOTS designates a Transportable Orbital Tracking Station, scheduled by WOTS, which can be moved to remote locations as a self-contained unit for on-location satellite tracking.

That portion of the WOTS which is undergoing the significant upgrade is identified by the designator WPS, and includes all the antennas and support equipment located within and in close proximity to Building N-162 at WFF. For ease of reference in this document, and for consistency with other documents, WOTS will be used interchangeably with WPS.

The major functions of the WOTS are tracking, commanding, data receipt, and data handling. Tracking includes a very high resolution determination of the distance to the spacecraft (range), and its angular position as a function of time, and is used to supply information to precision orbit prediction programs which are used to determine future spacecraft position. Commanding is used to send a sequence of information to the spacecraft to cause it to perform events and/or report its status, either immediately or in the future. Data receipt, also called telemetry, is the capture of data telemetered from the spacecraft by the tracking station. Data handling covers all elements of manipulating the data once it has reached the ground. Data handling includes checking the data for errors in real-time, recording the data, passing the data through the ground station and out to communication facilities for transmission to other sites, playing back previously recorded data and transmitting off-site, and playing recorded data within the ground station for end-to-end station testing. A support is designated as one or more of the above four functions with reference to a particular spacecraft.

The determination of the various elements of a support which are needed for a particular spacecraft at times in the future is made by the Wallops Scheduling Group (WSG). The WSG uses the Wallops Orbital Tracking & Range Scheduling (WOTRS) system, a UNIX workstation-based object oriented facility, to merge requests for support from the spacecraft project centers or other scheduling centers with spacecraft viewperiod information. The output of the scheduling process becomes the input to the tracking station, and is used to configure the equipment properly for a future spacecraft support. Although the acronym WOTRS implies scheduling for the WFF launch range, it presently only provides scheduling directives to the WOTS, including the TOTS when they are being used.

The Wallops Orbital Tracking Station, WPS, comprises one 18.3 meter receiving antenna, one 9 meter up/down link antenna, one 7.4 meter receiving antenna, one 6 meter uplink antenna, two VHF receiving antennas, two VHF command antennas, and the associated ranging, command, data acquisition, data formatting, data recording, and communications support equipment. The WOTS performs no data reduction services; ultimately, all data from the spacecraft is passed via communication facilities to the appropriate spacecraft Payload Operation Control Center (POCC). Conversely, all commands to the spacecraft are supplied by the POCCs for proper transmission to the orbiting satellite. High speed data transfer back to the POCCs (or other requester) is provided by NASCOM's Time Division Multiple Access (TDMA) system satellite uplink, and a NASCOM leased RCA earth station link. Figure 1 shows the high level external interfaces of the WOTS, and the data flow.

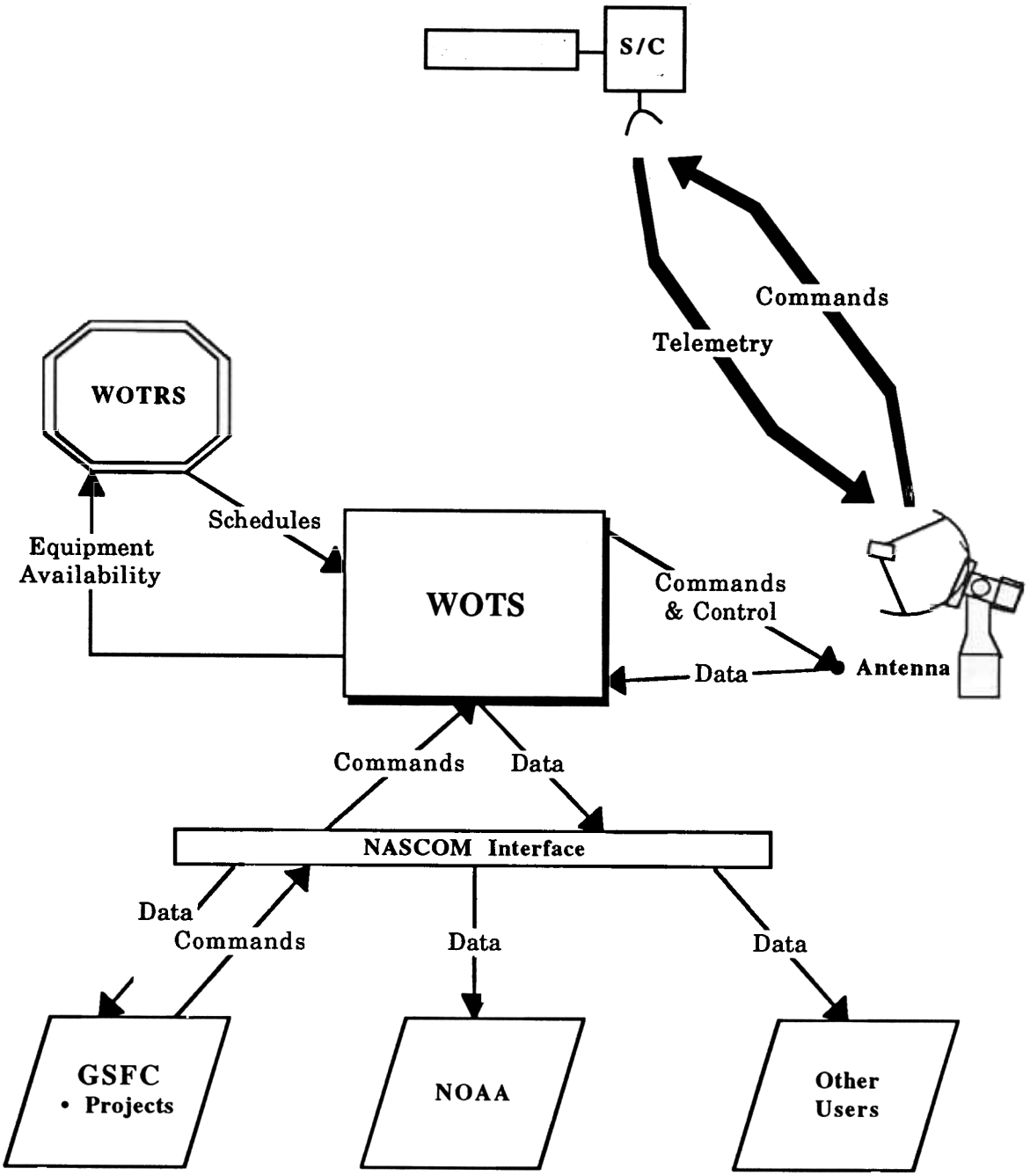

Figure 2

WOTS External Interfaces & Data Flow

The complement of spacecraft currently supported by the WOTS, and the list of known future spacecraft are shown in Table II, along with the antennas which are required for support. This list is subject to revision, especially as new spacecraft are added and the WOTS load is increased.

Table II - WOTS Current & Projected Supports

SATELLITES	S-Band 9M	S-Band 7.5M	VHF Down	VHF Up	UHF	X-Band	L-Band 7.5M	6M Up	18M	Launch Date
IUE	-	-	1	1	-	-	-	-	1	26-Jan-78
IMP-8	-	-	1	1	-	-	-	-	-	26-Oct-73
COBE	1	*	-	-	-	-	-	-	-	18-Nov-89
NOAA-10	-	-	-	-	-	-	1	-	-	17-Sep-86
TOMS	-	-	-	-	1	-	-	-	-	15-Aug-91
SAMPEX	1	*	-	-	-	-	-	-	-	3-Jul-92
ERBS	1	*	-	-	-	-	-	-	-	5-Oct-84
NIMBUS-7	1	*	-	-	-	-	-	-	-	24-Oct-78
ROSAT	1	*	-	-	-	-	-	-	-	1-Jun-90
LANDSAT	1	*	-	-	-	-	-	-	-	16-Jul-82 LSAT-4 1-Mar-84 LSAT-5
TDRS	1	-	-	-	-	-	-	-	-	
SPOT-C	1	**	-	-	-	-	-	-	-	25-Sep-93
GOES-I	1	**	-	-	-	-	-	-	-	1-Apr-94
TOMS-EP	1	*	-	-	-	-	-	-	-	19-May-94
ETS-VI	1	*	-	-	-	-	-	-	-	

* 7.5M/6M antenna configuration is the S-Band backup system (also used during simultaneous supports).

** 7.5M/6M antenna configuration is used simultaneously (Hot Back-up) with the 9M antenna during launch supports.

SATELLITES	S-Band 9M	S-Band 7.5M	VHF Down	VHF Up	UHF	X-Band	L-Band 7.5M	6M Up	18M	Launch Date
FAST	1	*	-	-	-	-	-	-	-	23-Aug-94
HELIOS-1A	1	**	-	-	-	-	-	-	-	1-Sep-94
SEAWIFS	1	*	-	-	-	-	-	-	-	22-Jul-94
GOES-J	1	**	-	-	-	-	-	-	-	1-Mar-95
SWAS	1	*	-	-	-	-	-	-	-	1-Jun-95
ADEOS	-	-	-	-	-	1	-	-	-	
SMEX-4	1	*	-	-	-	-	-	-	-	1-Jan-97
SMEX-5	1	*	-	-	-	-	-	-	-	1-Jan-98
GOES-K	1	**	-	-	-	-	-	-	-	1-Dec-98
SMEX-6	1	*	-	-	-	-	-	-	-	1-Jan-99
TIMED	1	-	-	-	-	-	-	-	-	1-Nov-98 (H) 1-Jan-99 (L)
GOES-L	1	**	-	-	-	-	-	-	-	1-Dec-99
SMEX-7	1	*	-	-	-	-	-	-	-	1-Jan-00
GOES-M	1	**	-	-	-	-	-	-	-	3-Dec-03
STS LAUNCH	1	**	-	-	-	-	-	-	-	ONGOING
STS ORBITAL	1	*	-	-	-	-	-	-	-	ONGOING
PEGASUS	1	-	-	-	-	-	-	-	-	ONGOING

* 7.5M/6M antenna configuration is the S-Band backup system (also used during simultaneous supports).

** 7.5M/6M antenna configuration is used simultaneously (Hot Back-up) with the 9M antenna during launch supports.

3.2 WOTS Upgrade Process

The technology currently used in the WOTS relies, to a significant degree, on connecting components for a support using hardwires in patch panels. Although some of the individual components have been upgraded over time, and may have the capability of control remotely by computer via an electronic interface, this capability is not being used widely, nor is there any station-wide central monitoring facility. The WOTS Upgrade Process has as its charter, therefore, the automation of station functions to the highest degree possible to increase both the total number of satellites which can be supported, and the number of simultaneous supports which can be conducted. Automating the WOTS will result in:

- Improved performance
- Improved availability for supports
- Improved maintainability
- Increased reliability
- Shortened turn-around time between supports
- Reduced costs.

As a part of the upgrade, some of the major hardware components also will be replaced, and an X-band receive capability will be added. A new 11 meter[1] S and X-band antenna will be procured to replace the hydraulically-driven 9 meter antenna. An upgrade will be made to the 7.4 meter antenna to enable a full uplink capability; this will replace the current 6 meter uplink antenna. Numerous pieces of support equipment also will be replaced with commercial off-the-shelf units having an enhanced capability for computer interface and control.

The goal of the WOTS upgrade is to automate as much of the routine station setup, checkout, and operation as possible using a group of small computers (PCs) at strategic nodes to control and monitor like pieces of equipment, and several centralized master computers to process information from the nodes. This concept will enable operators at the master computer consoles to control and/or check the status of all elements within the tracking station, and perform most of their duties from a single location. Centralized station set-up, station checkout, station operation, and fault isolation will greatly increase the efficiency of the station, and move even further along the path toward the goal of "faster and cheaper", which has always been a significant attribute of the WOTS.

[1] The new antenna, currently in the procurement stage, is designated as an 11 meter throughout this document; the specification calls for an antenna with a maximum diameter of 12 meters.

3.3 Current WOTS Operation

Nominally, 30 minutes prior to a real-time support the tracking station is configured for the support according to the requirements communicated to the station personnel from the scheduling group via the hardcopy Operations Schedule. Each of the component resources to be used are selected, configured, and tested manually. Finally, an end-to-end station test is run to verify readiness for the support. During the support, each area is monitored separately to insure continuity and data quality. For example, in the telemetry flow the transmission from the spacecraft is received at the station where the PCM information is demodulated, amplified, and coupled to a Bit Synchronizer (Bit Sync). The Bit Sync provides reconstructed data and synchronized clocks for use by the Frame Synchronizer (Frame Sync) and the Programmable Data Formatter (PDF). The Frame Sync provides prime frame synchronization of the data stream. The Frame Sync is used primarily as a data quality monitor, but can be used as a parallel or synchronous data source for the PDF, when needed. Three dual channel PDF units are the primary data handling devices in the telemetry process. The PDF blocks and multiplexes the data, and is capable of processing many different data streams simultaneously. Data and clock signals are supplied to the PDF by the Bit Syncs. Blocked data is then sent to the NASCOM area for transmission off-site, and eventually to the user of the data. During the real-time process the data also is recorded as a back-up for re-transmission later, if required. If the playback of previously recorded data is scheduled, the equipment and station checks are not necessary, and the set-up is minimal.

4.0 OPERATIONS CONCEPT

4.1 Operational Environment

In the upgraded WOTS configuration the four basic functions of the tracking station (tracking, commanding, data receipt, and data handling, as described in Section 3.1 of this document) will still be performed. The major difference will be the degree of automation of the station functions, and the centralization of control.

In order to describe the operational concept, it is necessary to understand the new environment which will be created as a result of the upgrade. The various resources which are used during a support, and which enable one or more of the basic station functions to be executed, may be grouped according to general characteristics and similar control/status reporting requirements. A group of similar resources will be pooled together and interfaced to a small dedicated computer (PC), which will communicate with its resources via serial ports, parallel ports, or ISA cards. All configuring, controlling, and testing (readiness and diagnostic) will be performed under the control of the node computer, which is designated as a Remote Node . Each Remote Node will be furnished with special real-time software, developed by Code 822.4, running under the new Windows NT multi-tasking operating system. Although each Remote Node will interface with its resources using specially written software, the look and feel of all Remote Nodes will be very similar as a result of a uniform GUI philosophy. Each of the Remote Node computers will be equipped with Ethernet cards for communication with the three Master Subsystem computers via a Local Area Network (LAN). The Remote Nodes will monitor all of their component resources, and provide varying levels of status feedback to the Masters, as requested. Furthermore, the Master Subsystem will employ the same Input/Output screens as each Remote Node so the Remote Node functions can be executed remotely at the Masters.

The current WOTS upgraded configuration calls for 10 Remote Nodes. Figure 3 depicts a high level functional layout of the nodes within the WOTS configuration (noting that Node #9, NCPS, has been included with the Tracking and Command Node). Table III lists the name of each node, its component resources, and its generalized function. Figure 4 shows a typical support configuration using the new 11 meter antenna system. All four station functions are performed in this type of support.

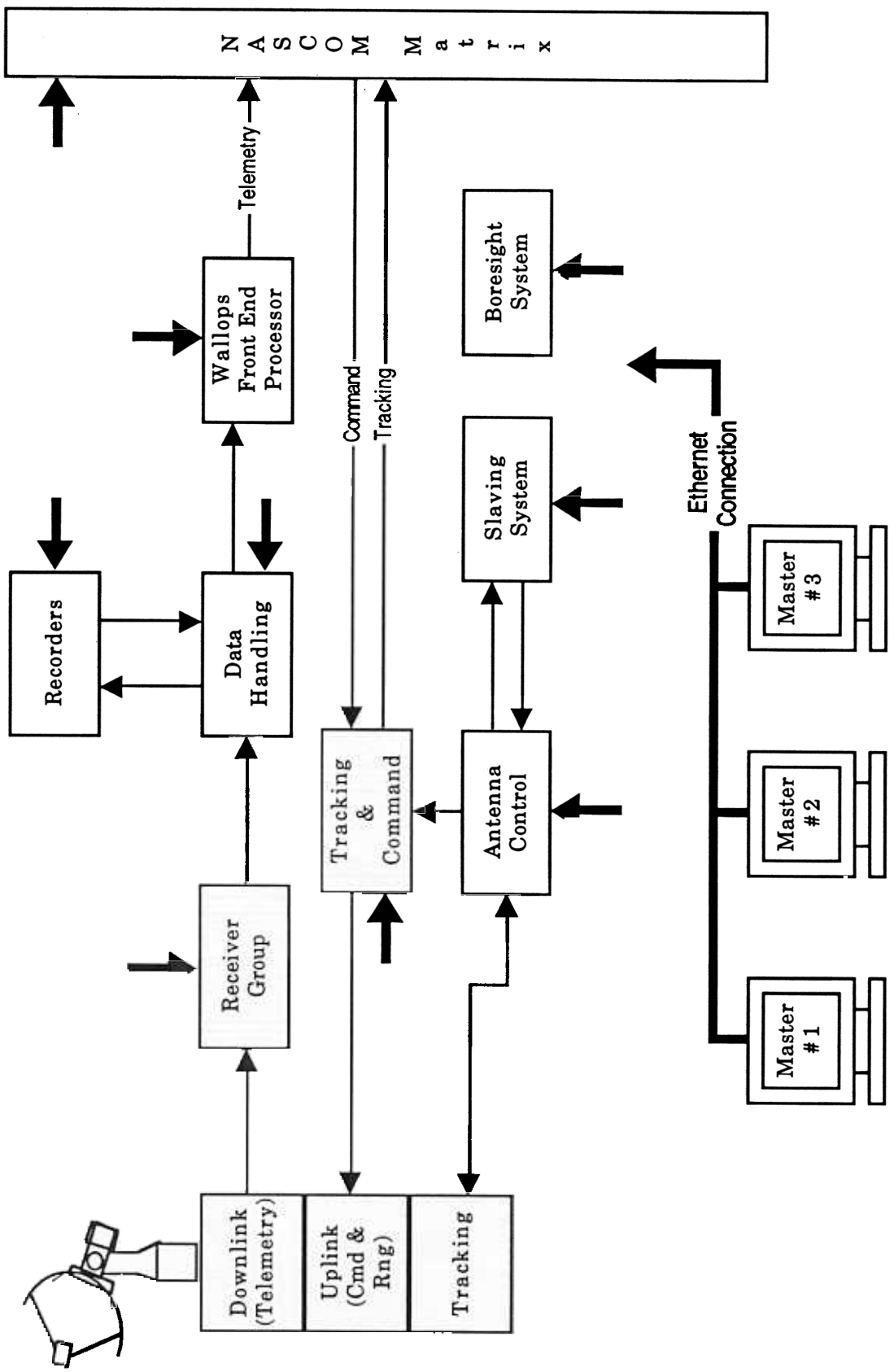

Figure 3 - Wallops Orbital Tracking Station Overview

Table III - WOTS Remote Nodes

Node #	Node Name	Resources	Function
1	Antenna[2]	Antenna Control Unit Receivers / Combiners Timing Exciter & Amplifier[3]	Antenna Control
2	Data Handling	PSK Demodulators Bit Syncs Frame Syncs TDPlus	Demodulation & Data/Clock Synchronization
3	Tracking & Command Data	Time Capture Units TCPS / NCPS Tracking Data Formatters Ranging	Tracking, Commanding, Ranging
4	WFEP	Wallops Front End Processor[4]	Packetization & Local Commanding
5	NASCOM	NASCOM Matrix Block Error Detectors Ephemeris Data	Communications
6	Data Recorder	Metrum Data Tape Recorders	Data recording & Playback
7	LTAS/MDDF	LTAS/MDDF	Provides slaving data
8	Receiver Bank	Receivers / Combiners	Used to supplement the antenna receivers & combiners
9	NCPS	NCPS	Receives commands & uplinks them to S/C
10	Boresight	Boresight System	Boresighting

[2] There are four antenna sub-nodes: one for the 11 m antenna, two for the 7.3 m antennas, and one for the ADAS.

[3] Only available on the 11 m antenna and one of the 7.3 m antennas.

[4] There are four WFEP sub-nodes.

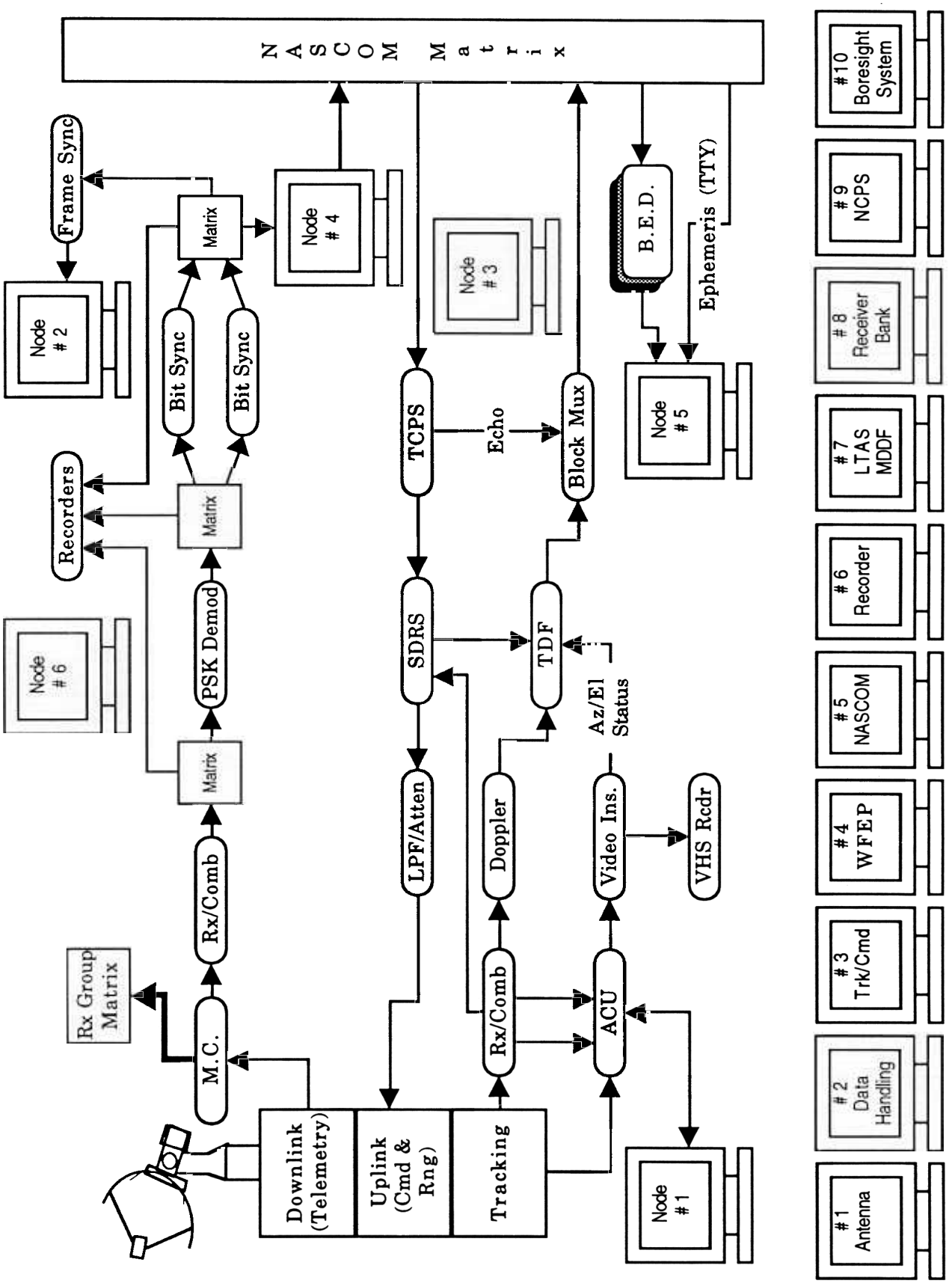

Figure 4 - WOTS Support Configuration with 11 m Antenna

4.1 Operational Modes

For purposes of designing software, the Wallops Orbital Tracking Station is considered to have two distinct modes of operation: Support Mode and Test Mode. Support Mode comprises all operations which are performed to facilitate a support. Test Mode covers all operations not directly connected with a particular support. Support and Test can be further subdivided as follows:

Support Mode

- Design Support Template
- Configure Station for Support
- Perform Support
- Record Support Statistics

Test Mode

- Perform Diagnostic Tests
- Perform Preventive Maintenance

Design Support Template is the process of assimilating schedule information from the WOTRS system designating the resources needed for a particular support, editing the information, and storing the information as a template for future use. In this operation, no interaction with the remote nodes is necessary, and no actual configuring of resources is done. Configure Station for Support comprises all operations which must be performed prior to initiation of a support, including complete end-to-end station readiness verification. Perform Support includes all activities which occur during a support, from initiation of the acquisition of signal (AOS) sequence to loss of signal (LOS), including any pre or post station calibrations. Record Support Statistics designates the process of retrieving usage and status data from the remote nodes, assembling the information, and storing the information for later retrieval and/or input to the WOTRS system. Maintenance, in general, covers all levels of testing, with the exception of station readiness testing. Perform Diagnostic Tests is focused on isolating and correcting problems, and may cause component resources to be driven to their limits while diagnostics are being run. Perform Preventive Maintenance focuses on keeping equipment operating within proper specifications, and may include the calibration of individual pieces of equipment, or subset strings of resources.

The mapping of the WOTS operations to those of the Master Subsystem is one-to-one, since the Master Subsystem, together with the station operators, must perform the basic station functions. The Remote Nodes Subsystem, on the other hand, will carry out all the operations designated by the Master, but will not, itself, differentiate between the subdivided categories of station operation.

4.1.1 Support Mode

Design Support Template

- The WOTRS system will supply the WOTS with the Operational Schedule, which contains the support requirements for the current operational week.

The user will identify a particular support by specifying a unique support ID, or other distinguishing attributes.

- The user may create/modify a list of component resources (equipment) that will be needed for the support.
- The user will configure the equipment for the support by choosing to edit a previous support template, to use a support template based on the support type, or to create a new support template.
- The user may initialize/modify configuration values and settings for the equipment. This may done using a worksheet format or through interaction with the graphical display. No data will be sent to the Remote Nodes.

  The completed template can be stored for later retrieval to begin the process of station configuration.

Configure Station for Support

- The user may review all current scheduling information.
- The user may review and/or modify the proposed data flow as stored in the support template. Modifications will be made through interaction with the graphical display.
- The user may initialize/modify configuration values and settings for the equipment. This may done using a worksheet format or through interaction with the graphical display. The completed data will be sent to the appropriate Remote Node, and confirmation of receipt and action will be given.
- The user may initiate a pre-designated station readiness test.
- Before the status is considered to be green for the support (i.e. all needed resources on-line & ready), each remote node will have to be in a green status.

Perform Support

- The user may review equipment status and equipment settings for all resources dedicated to the current support. No modifications will be allowed without proper interaction with the Master, and without complying with established security procedures (e.g. a password). Inspection and/or modification may be done through interaction with the graphical display.
- The user may review and/or modify equipment selections through interaction with the graphical display. New selections will be subject to appropriate security procedures and availability of equipment.
- The user will be warned when a problem is detected. Warnings will cause a change in the graphical display.
- The user may review the status of all equipment in the WOTS, including equipment not dedicated to the current support.

- The user may review scheduling information.
- The user may manually initiate a support.

Record Support Statistics

- The remote nodes will report errors and/or warnings encountered during the support, and will report to the master when requested.
- The master subsystem will maintain a record of the setup used, errors and/or warnings encountered, information from the remote nodes, etc. for post-support reference, and for historical record-keeping.
- The master subsystem will report back to the WOTRS scheduling system designated information, such as successful completion of the support, resources used, and station metrics.

4.1.2 Test Mode

- The user may select a particular resource, and, either directly on the appropriate remote node or from the master, by interacting with the maintenance menus already in place, perform testing. Diagnostic testing, for the purpose of fault isolation, may require a special set of interactive menus. Preventive maintenance will be used for calibrating or otherwise enhancing the functionality of particular resources. Between the master and the remote nodes, all levels of testing will be supported, and all test procedures will be provided.

5.0 REQUIREMENTS SPECIFICATION

The requirements imposed upon the WOTS system are divided into the External Requirements, which control how each subsystem must communicate with the world outside of itself, Functional Requirements, which specify what functions the subsystems must be able to perform, and General Requirements. The Functional Requirements have been subdivided into Support Requirements and Test Requirements, according to the categorization used in Section 4.1 above. For the purpose of traceability, the requirements for the Master Subsystem and the Remote Nodes Subsystem are categorized separately, where appropriate.

Other aspects addressed in this section in a less stringent manner are Performance Requirements, Safety Requirements, Security Requirements, Implementation Constraints, Site Adaptations, and Design Goals.

5.1 Interface Requirements

Master Interface Requirements (IM)

IM.1 - Receive schedule from WOTRS

The Master shall be able to receive the Operational, Strawman, and Forecast schedules from the WOTRS system without operator intervention.

IM.2 - Communicate with the Remote Nodes

The Master shall be able to communicate with any of the Remote Nodes via an Ethernet interface.

IM.3 - Interruption by Remote Nodes

Priority communications from a Remote Node shall be processed for immediate display on the Master.

IM.4 - Send support statistics to WOTRS

The Master shall be able to send WOTS performance data to the WOTRS upon the completion of a support.

IM.5 - Send resource availability to WOTRS

The Master will send information about availability of resources to the WOTRS system without operator intervention.

Remote Node Interface Requirements (IR)

IR.1 - Communicate with the Master

The Remote Nodes shall be able to communicate with the Master via an Ethernet interface.

IR.2 - Communicate with Resources

Each Remote Node shall be able to communicate with its resources. This is to be accomplished using dedicated interface cards, or RS-232 ports, or IEEE-488 ports.

5.2 Functional Requirements

Master Support Requirements (SM)

SM.1 - Configure resources via Remote Nodes

The Master will provide an interface to each resource to be used in a support through which configuration values, settings, etc. can be set. Information will be sent to the Remote Node.

SM.2 - Check resource status

The Master will provide an interface to each resource by which its status can be checked.

SM.3 - Check station

The Master will provide an interface by which a station readiness test can be conducted.

SM.4 - Identify support

The Master will provide an interface by which a particular support can be identified; the support may be identified using a unique support ID, or some combination of characteristic information, such as S/C ID, launch date, mission information, etc.

SM.5 - Support templates

The Master will maintain a list of support types and/or previous support set-ups that can be accessed as a template for new supports.

SM.6 - Select equipment manually

The Master will provide an interface from which the user can select the resources needed for a support. This information will be passed on to the appropriate Remote Node(s).

SM.7 - Select equipment automatically

The Master will provide the capability of selecting all the resources needed for a support automatically from the support template. This information will be passed on to the appropriate Remote Node(s).

SM.8 - Check resource availability

The Master will obtain information from the Remote Nodes indicating which resources are available.

SM.9 - Remote Node selection override

The Master will provide a means by which specific equipment selections made automatically by a Remote Node can be overridden.

SM.10 - View proposed support data flow

The Master will provide a graphical display showing the proposed data flow for a support. The proposed data flow will be based on standards and/or defaults.

SM.11 - Modify support dataflow

The Master will provide an interface by which the proposed data flow for a support can be modified through interaction with the graphical display.

SM.12 - Conflict detection

The Master will verify that the details specified for a support do not cause conflicts with other supports using information available from the WOTRS system and Remote Nodes.

SM.13 - Schedule display

The Master shall be able to display the Operations, Strawman, or Forecast schedules in graphical timeline format.

SM.14 - View support data flow

The Master will provide a graphical display of the data flow through all the resources associated with the support.

SM.15- Monitor equipment status

The Master will provide an interface to each type of equipment to be controlled by which settings, status, etc. can be monitored.

SM.16 - Modify resources

Modifications to resources will be allowed at the Master Subsystem level upon proper notification of the appropriate Remote Node, and upon compliance with its established security procedures (e.g. a password).

SM.17 - Alarm equipment malfunction

The Master will include an error warning display mechanism that indicates when equipment status checks have indicated a problem. The display will indicate the Remote Node affected, the individual resource involved, the type of problem, and the resolution status (resolved automatically or needing intervention).

SM.18 - Propose equipment failure resolution

The Master will propose resolutions to equipment problems/failures, if requested.

SM.19 - View all resources

The Master will provide a means by which the status of all WOTS resources, including resources not dedicated to the current support, can be obtained.

SM.20 - Browse WOTRS system schedules

The Master will allow any of the WOTRS system schedules within the current scheduling horizon to be browsed.

SM.21 - Automatic support initiation

The Master will automatically notify each of the resources associated with a support to begin processing at a predefined time.

SM.22 - Manual support initiation

The Master will include a manual start-up capability.

SM.23 - Report generation

The Master will enable reports to be generated which include user specified support summary information (e.g. configuration values, errors encountered).

Remote Node Support Requirements (SR)

EC.3 to CRN

SR.1 - Configure equipment Not for CRN but will be added for AWOTS

The Remote Nodes will provide an interface to each type of equipment to be controlled by which the configuration can be set.

SR.2 - Execute complete command set EC.2

The Remote Nodes will implement the complete command set for a resource.

SR.3 - Monitor & report node status [redacted]

Each Remote Node will monitor the status of itself and report conditions to the Master.

SR.4 - Monitor equipment status EM.1

Each Remote Node will monitor the status of all its equipment.

SR.5 - Report equipment status EM.2

Each Remote Node will provide varying levels of status feedback to the Masters as requested.

SR.6 - Report equipment availability ER.1

Each Remote Node will provide the Master with information on equipment availability.

SR.7 - Detect equipment failure EM.3

The Remote Nodes will detect equipment failures and inform the Master.

SR.8 - Initiate automatic recovery

The Remote Nodes will provide procedures for automatic recovery in the event of equipment failure. This may be carried out at the individual unit level, automatically.

SR.8 - Respond to a general request ER.2

The Remote Nodes will respond to a request for a "general" resource (i.e. a bit sync)

SR.10 - Respond to a specific request ER.3

The Remote Nodes will respond to a request for a "specific" resource (i.e. bit sync #5).

SR.11 - Log status of support

The Remote Nodes will send logged status information to a Master for archiving and report generation.

SR.12 - Provide support security

The Remote Nodes will provide for warning messages and password protection before allowing changes to resources which are in use for a support.

Master Test Requirements (TM)

TM.1 - Conduct tests from Master

The Master will be able to conduct all levels of corrective and preventive maintenance tests which are available at each Remote Node.

Remote Node Test Requirements (TR)

TR.1 - Diagnostic testing

The Remote Nodes will be able to conduct all levels of diagnostic tests, appropriate to the equipment they control.

TR.2 - Preventive maintenance

The Remote Nodes will be able to conduct all levels of preventive maintenance tests, including calibrations, appropriate to the equipment they control.

5.3 General Requirements

User Interface (U)

U.1 - Consistent look & feel

The system shall employ an integrated dialog which provides a consistent graphical look and feel.

U.2 - Minimum number of process levels

The system shall minimize the number of process levels in order for a user to perform routine functions.

U.3 - Horizontally scrollable display windows

The system shall accommodate horizontally scrollable display windows.

U.4 - Vertically scrollable display windows

The system shall accommodate vertically scrollable display windows.

U.5 - Mouse button interaction

The system shall accommodate one or more buttons on a mouse, whenever a mouse is used.

U.6 - Overlaid windows

The system shall be able to display overlaid windows simultaneously.

U.7 - Resize & drag windows

The system shall be able to resize and drag windows.

U.8 - Crosshair graphic

The system shall provide for the use of a crosshair graphic to aid in locating the cursor and reading across a line of text.

U.9 - Form-based data entry

The system shall incorporate a textual form-based user interface for data entry and editing.

U.10 - On-line user help and diagnostics

The system shall incorporate a context sensitive on-line help function to answer user questions during a session, and to help the user clarify and resolve error traps.

Database (D)

D.1 - Support templates

The Master will keep all support template information available in a form for immediate use.

D.2 - Support statistics

The Master will save a record of the setup used, errors and/or warnings encountered, equipment changes, etc. for post-support reference.

5.3 Performance & Quality Engineering Requirements

System Performance

No specific requirements have been generated yet addressing a measurable system performance metric. The system must be able to set-up and monitor three simultaneous supports for the WOTS, and continuously process information from any of the Remote Nodes.

Error Handling

The system shall be able to detect common user errors, flag them with clear and informative messages, and loop back for corrected input. Where an error occurs at a lower level within a series of nested screens, the error should be correctable locally within the affected screen; it should not be necessary to navigate from the root screen through several levels to relocate the working screen.

Reliability, Maintainability, Portability

The WOTS control and monitoring software shall be well tested and robust so there is little chance of a system crash or other anomaly which could cause the destruction of data. It is expected that all code generated for the system will meet NASA/WFF Code 822.4 coding standards, and all routines will contain internal documentation to describe their purpose, history, external interfaces, control and processing flow, and any unusual attributes. The run-time modules should be self-contained so they can be moved to another platform having like capabilities.

5.4 Safety Requirements

There are presently no known safety requirements levied upon this software.

5.5 Security and Privacy Requirements

It is important, in an operational environment, to insure that all key files are under the control of the WOTS shift leaders, and only authorized users are able to use the system and/or modify the files. The WOTS operational software should be protected at two levels, as a minimum. First, the platform on which the software operates should be password protected at the operating system level; only persons with the current password should be able to use the system at all. Secondly, critical files in the operations directory may be write protected, where possible; they can be used, but not modified without authorized access.

It is mandatory, also, that the software and all data files be backed-up to protect against possible hardware system failure. Procedures should be put in place within the WOTS to this effect. Both the executable software image and all source files will be placed under configuration management, and should be stored on high-density media. Before a new version of the software is released, it will be thoroughly tested, proper documentation generated, and tape archive copies made. The critical data files within the operations process should be backed-up to an appropriate medium regularly.

5.6 Implementation Constraints

The hardware being procured for the Master and Remote Nodes Subsystems has been specified as PC platforms, each having an Intel Pentium based processor (minimum 486) with an ISA bus. All platforms used are to be identical, with the exception of the specific Remote Node interface cards. This will facilitate quick and easy replacement of hardware in the event of a node failure. The software written for the WOTS Upgrade will have to be compatible with the PC workstations, all of which will have the Windows NT real-time, multitasking

operating system installed. Each Remote Node also will have the complete complement of node software, also for ease of replacement in case of a failure.

5.7 Site Adaptation

There will be significant site modifications made to the current WOTS physical facilities. These are required by the new Telemetry hardware systems being procured, and the need to have a parallel operation with the old and upgraded systems running simultaneously. This is not expected to have any detrimental effect on the software development effort.

5.8 Design Goals

The new WOTS Upgrade software will be designed and released in Builds, each with increasing capabilities. Prototyping will be used extensively, and user screens will be designed in close coordination with the Data Acquisition Branch (Code 833), Telecommunications Section operations personnel, who will be the final users of the system.

6.0 PARTITIONING FOR PHASED DELIVERY

WOTS software will be released in a series of four phases.

Phase 1:

This phase is essentially a prototype phase. It will consist of software developed in the nine month period spanning from February to October 1994. Software released in October 1994 will be used to solidify the basic philosophy of the WOTS design. It will provide a baseline from which engineers and WOTS users can begin to interact with actual Master and Remote Node computers so that more detailed comments and inputs concerning interfaces and functionality can be obtained. Expected functions developed during this phase are:

- Limited Master interface and functionality
- Recorder Remote Node functionality
- Boresite Remote Node functionality

  Limited interface to Scheduling System

  Limited Data Handling Remote Node functionality

Phase 2:

Approximately one year after the beginning of the prototype phase Build 1 will be initiated. This phase will produce a more stable and functional release of the WOTS software. Installation of Build 1 software is expected in November 1995. This phase will not, however, comprise an operational delivery of software, and will, again, provide additional capability with the purpose of obtaining still more user and engineering interaction with the system. Expected functions to be installed in this phase are:

- Master interface with limited functionality
- Recorder Remote Node
- Boresite Remote Node
- Scheduling System interface
- Data Handling Remote Node
- WFEP Remote Node
- 11M interface
- Slaving System Remote Node

Phase 3:

One year following the release of Build 1, Build 2 is scheduled for completion. This build can be termed a Beta version of the operational software. All major

subsystems will be in place and all major subsystem functionality is expected to be provided. Build 2 is to be installed in October 1996. Expected software to be installed in this phase will support the following:

- Multiple Masters
- 11M Antenna
- 7.3 M Antenna
- 7.3 M Antenna (receive only)
- ADAS Antenna
- WFEP Remote Node
- Boresite Remote Node
- Tracking and Command Remote Node
- Recorder Remote Node
- Receiver Group Remote Node
- Data Handling Remote Node
- NCPS Remote Node
- Slaving System Remote Node
- NASCOM Remote Node
- Scheduling System interface
- Limited TOTS functionality

Phase 4:

Phase 4 activities consist of final system testing, any changes necessary to meet test criteria, and system acceptance. The end of phase four marks the delivery and conversion to operational status of the WOTS Upgrade software. All functionality will be delivered and installed on all WOTS subsystems. Software will be under hard configuration control as described in the Software Development/Management Plan. Sustaining engineering efforts will then commence using the Code 822.4 RFS documented software maintenance procedures. Software release is scheduled for July 1997.

7.0 ABBREVIATIONS AND ACRONYMS

	Advanced Data Acquisition System
ACS	Acquisition of Signal
BED	Block Error Detector
DSN	Deep Space Network
GN	Ground Network
GSFC	Goddard Space Flight Center
GUI	Graphics User Interface
ISA	Industry Standard Architecture
JPL	Jet Propulsion Laboratory (Pasadena, California)
	Local Area Network
	Loss of Signal
LPF	Low Pass Filter
LTAS	Launch Trajectory Acquisition Sytem
MDDF	Minimum Data Delay Format
MFRS	Multi-Function ReceiverS
MVX	Multiplexer
NCPS	Network Command Processing System
PCM	Pulse Code Modulation
	Programmable Data Formatters
POCC	Payload Operation Control Center
PSK Demod	Phase Shift Key Demodulator
RFS	Request for Support
S/C	Spacecraft
	SpaceCraft EncoderS
SDRS	(S) Digital Ranging System
SRE	STDN Ranging Equipment
STDN	Spaceflight Tracking & Data Network
	Transportable Command Processing System
TDF	Tracking Data Formatter
TDMA	Time Division Multiple Access
TDPlus	Telemetry Data Processor +
WFEP	Wallops Front End Processor

WFF	Wallops Flight Facility
WOTRS	Wallops Orbital & Range Scheduling
WOTS	Wallops Orbital Tracking Station
WSG	Wallops Scheduling Group

8.0 GLOSSARY

Resources	In the context of WOTS, individual pieces of equipment needed for a support, or small groups of equipment which function as a logical unit.
Support	One or more of the four basic functions (tracking, commanding, data receipt, data handling) performed by a tracking station with reference to a particular spacecraft.